Semiarid Precipitation Frequency Study

Update of *Technical Paper No. 40, Technical Paper No. 49* and *NOAA Atlas 2*

Twenty-second Progress Report
1 July 2002 through 30 September 2002

Hydrometeorological Design Studies Center
Hydrology Laboratory

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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk

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Update of *Technical Paper No. 40, Technical Paper No. 49* and *NOAA Atlas 2*

1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for the Semiarid Southwestern United States. Current precipitation frequency estimates for the Semiarid region are contained in *Technical Paper No. 40* "Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years" (Hershfield 1961), *Technical Paper No. 49* "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al 1964) and *NOAA Atlas 2* "Precipitation-Frequency Atlas of the Western United States." The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual all-season precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Semiarid study area and use accepted statistical methods. In particular, the Semiarid Study is the pilot study in which decisions regarding the methods and format are being made that will affect subsequent studies. The study results will be published as Volumes of *NOAA Atlas 14* on the internet using web pages with the additional ability to download digital files.

The Semiarid study will produce estimates for 4 states completely, Arizona, Nevada, New Mexico, and Utah, and southeastern California. Additional data from 7 bordering states and Mexico (Figure 1) are included for continuity across state borders. The core and border areas and regional groups for long duration (24-hour through 60-day) analyses are shown in Figure 1. Regional groups for short duration (60-minute through 12-hour) analyses are shown in Figure 2.

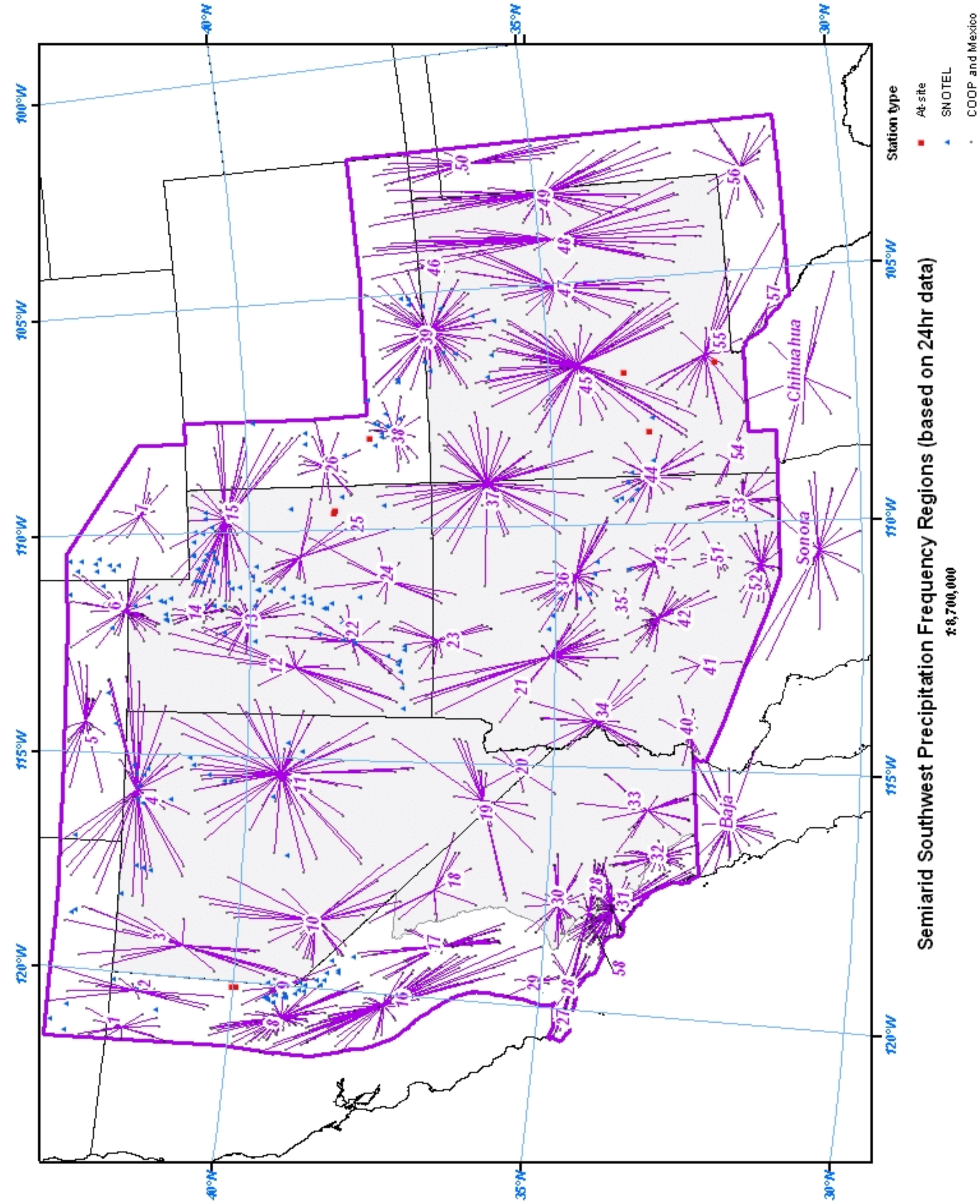


Figure 1. Semiarid Precipitation Frequency study area and new regional groups for 24-hour and longer duration values.

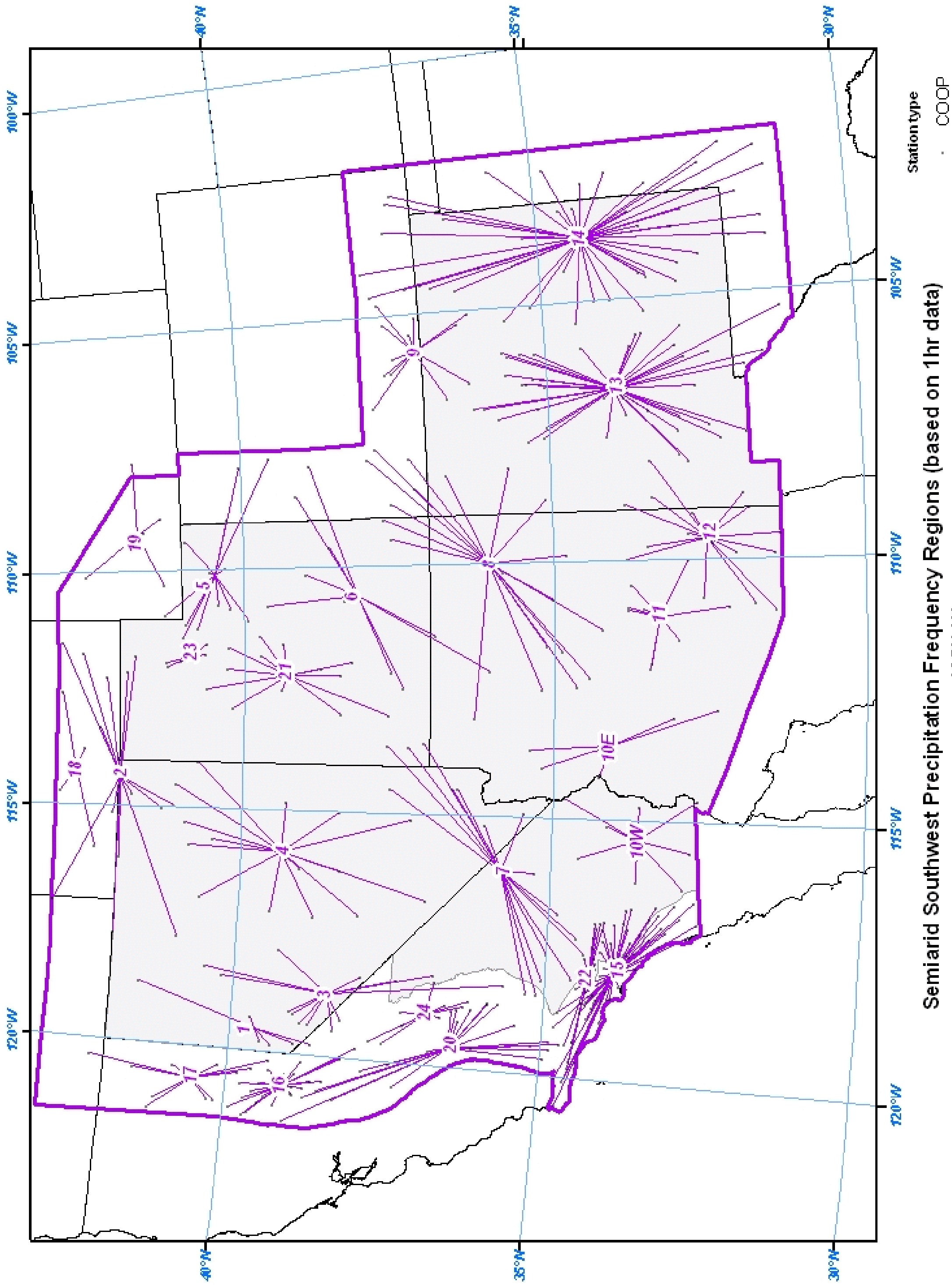


Figure 2. Semiarid Precipitation Frequency regional groups for 12-hour and shorter duration values.

2. Highlights.

The Semiarid observing-site precipitation frequency estimate peer review took place between June 27 and July 26, 2002. The review was a success and proved to be an invaluable part of this project. Most of the suggested changes have been fully evaluated and resolved. Some post-review interactions have taken place between HDSC and reviewers to ensure we have fully addressed and resolved their concerns. Additional information is provided in Section 4.1, Peer Review.

As a direct result of the peer review, additional hourly gages were identified and added to the hourly dataset. Also, appropriate n-minute stations were summed to 60-minutes and folded into the hourly dataset. Additional information is provided in Section 4.2, Data Addition.

The precipitation frequency values for SNOTEL stations have been calculated using the regional growth factors (RGF's) of the regions in which they reside. These values are necessary for the preparation of the final precipitation frequency maps. Additional information is provided in Section 4.3, L-moment Analysis.

Internal consistency software was revised to adjust quantiles through the 24-hour duration for hourly-only stations. Software was developed to adjust quantiles for co-located hourly and daily data, particularly across the 12-hour to 24-hour durations where disconnects have been observed. Lastly, software has been written to calculate conversion factors from annual maximum series to partial duration series which will be part of the final deliverable. Additional information is provided in Section 4.4, Development of Software.

Statistical tests were run to determine if there is any linear trend or shift in mean of the 1-day annual maximum series at eligible stations in the entire study area. It was found that, overall, there is no significant linear trend or shift in mean in the data at the 90% confidence level. Additional information is provided in Section 4.5, Trend and Shift Statistical Analysis.

In addition to the 12- and 24-hour durations, it was decided that temporal distributions of extreme rainfall will be produced for the 4-day duration. Additional information is provided in Section 4.6, Temporal Distributions.

On July 30, 2002 Geoff Bonnin and Tye Parzybok traveled to the Spatial Climate Analysis Service (SCAS) at Oregon State University, Corvallis, Oregon to discuss and obtain the first draft PRISM-interpolated Semiarid mean annual maxima (a.k.a. "index flood") grids for 1-hour and 24-hour. The successful all-day meeting involved technical discussions about the grids and PRISM. Additional information is provided in Section 4.7, Spatial Interpolation.

The Semiarid observing-site peer review allowed users to not only review the Semiarid precipitation frequency estimates, but the Precipitation Frequency Data Server (PFDS as well. The PFDS held up well during its first debut, and a tremendous amount of valuable input was received and quickly incorporated into the PFDS. Additional information is provided in Section 4.8, Precipitation Frequency Data Server.

A brief outline for the final documentation of the Semiarid Project has been revised to reflect relatively recent changes in methodology. A detailed outline, which will include theme and length of each section, is being written. Additional information is provided in Section 4.9, Documentation.

Progress towards the development of depth-area-duration (D-A-D) reduction relationships for areas from 10 to 400 square miles continues. The progress includes the identification of four additional study areas, completion of quality control on the existing eight study areas, and testing of the initial computer programming. Additional information is provided in Section 4.10, Depth Area Duration Study.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percent completed per task. Past status reports should also be referenced for additional information.

Semiarid study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [100%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Additional hourly data was added in Maricopa County, AZ and Riverside County, CA. The datasets are complete pending additional quality-controlled data received in a timely manner for Albuquerque, NM.

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [100%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

L-moments were re-run on regions that were affected by the addition of new hourly data. L-moments were also re-run on all regions using the new software to adjust co-located daily and hourly stations for disconnects. The revised results are complete.

Spatial Interpolation [50%]

- Create mean annual maximum (a.k.a. "Index flood") grids with PRISM for each duration (1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day)
- Apply a precipitation frequency map derivation procedure, known as the cascade residual add-back (CRAB) procedure to create a total of 162 grids. The same procedure will be used to create 162 upper and 162 lower bound precipitation frequency grids. (See Section 4.6 Spatial Interpolation for more details.)

- Apply study-wide conversion factor to the 60-minute precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids

Draft grids of spatially interpolated mean 1-hour and 24-hour annual maxima values (a.k.a. "index flood") were delivered from the Spatial Climate Analysis Service (SCAS). Software was written to convert these "index flood" grids to precipitation frequency maps. After the review of the draft grids and maps for the 1-hour and 24-hour durations, the remaining maps can be quickly generated.

Peer Reviews [50%]

- Lead review of point precipitation frequency estimates
- Lead review of spatial interpolation grids

The review of observing-site precipitation frequency estimates was completed. HDSC responded to reviewer comments and made changes based on their recommendations. The "index flood" grids and draft precipitation frequency maps for the 1-hour and 24-hour durations will be reviewed next.

Data Trend Analysis [95%]

- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)

The trend and shift analyses of 1-day annual maximum series are complete. Results are being fully reviewed and the documentation is nearly complete.

Temporal Distributions of Extreme Rainfall [80%]

- Assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- Sort, average, and plot time distribution of hourly maximum and median events for different climatological regions and seasons

Temporal distributions for 12- and 24-hour durations are complete. An additional 4-day duration will also be computed.

Deliverables [50%]

- Prepare data for web delivery
- Prepare documentation for web delivery
- Write hard copy of Final Report
- Publish hard copy of Final Report

A detailed outline of the final documentation is being written. The Precipitation Data Frequency Server (PFDS) has been modified to reflect changes suggested by reviewers.

Additional Work:

Spatial Relations (Depth-Area-Duration Study) [40%]

- Obtain hourly data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot
- Prepare curves of best fit (depth-area curves) for each duration and network

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a separate volume of NOAA Atlas 14.

4. Progress in this Reporting Period.

4.1 Peer Review.

The peer review of Semiarid observing-site precipitation frequency estimates took place between June 27 and July 26, 2002. Out of roughly 84 reviewers, we received comments from 25, or about 30%. We heard from experts in each of the core states (AZ, CA, NM, NV and UT), with the greatest number of comments coming from Arizona and California. After parsing all of the comments, there were 74 unique comments that required our feedback.

The majority of the comments pertained to the PFDS (32), however the solutions to these were easy software changes/fixes (See PFDS Update section). The most significant data related issues included: unusual steps or changes in slope in the depth-duration frequency curves and significant differences between our results and storm events and/or NOAA Atlas 2.

In order to allow all of the reviewers the opportunity to see what other reviewers commented on, we prepared a master document containing the parsed comments and our responses to them without identifying the reviewer. The wording of the comments was unchanged to make sure the meaning was not misconstrued and so reviewers could identify their own comments.

The review was successful and proved to be an invaluable element of this project. Most of the suggested changes have been fully evaluated and resolved. Some post-review interactions have taken place between HDSC and reviewers to ensure we have fully addressed and resolved their concerns.

4.2 Data Addition.

4.2.1 Additional Hourly Stations.

As a direct result of the peer review process, data from an ALERT (Automated Local Evaluation in Real Time) network in and around the Flood Control District of Maricopa County, Arizona were added to the hourly dataset. 28 stations were added to hourly regions 8, 10E and 11. These data were also incorporated into the 24-hour analysis for daily regions 21, 34, 35, 41, and 42. The addition of the stations increases the spatial density for the Phoenix area. There was no real change (±1-5%) in the precipitation frequency estimates for all regions, except for hourly region 11 where the estimates increased (+13-14%).

Other networks, including Pima County AZ, Reno NV, and Salt Lake City UT, were researched but none met our minimum criteria to be included. An Albuquerque, New Mexico network may be available in the near future. If the schedule allows it, this dataset will be included in our analysis.

4.2.2 N-minute Stations.

Appropriate n-minute stations were summed to 60-minutes and folded into the hourly dataset. All but one NCDC n-minute data station are co-located with hourly data and so were not summed. Five n-minute stations from the Riverside County Flood Control District in California were incorporated into the hourly dataset. 1-hour through 48-hour annual maximum series were extracted. Shorter durations will be calculated for these stations using the 60-minute quantile and the appropriate global n-minute ratio. Two Riverside stations were added. The data of three stations were replaced with the Riverside data because the Riverside stations had longer data records and because the Riverside data for these stations had been extensively quality controlled to include reconstructed storms that our previous data did not have. The added and substituted data affected hourly regions 10W and 15 and daily regions 31, 32, and 33. The addition of these stations did not significantly alter precipitation frequency estimates for other stations in the regions. The 100-year quantiles of the substituted stations, Hurkey Creek, CA (04-4181) increased slightly (~2%) and San Jacinto, CA (04-7813), increased by ~6%. There was no real change in the 100-year quantiles of Elsinore, CA (04-2805).

4.3 L-moment Analysis.

In the previous quarter, 186 SNOwpack TELemetry (SNOTEL) daily stations were added to the dataset to increase the spatial density of stations particularly at higher elevations. Mean values for the 24-hr, 48-hour, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, and 60-day durations will be used in the spatial interpolation by PRISM. However, the quality of the data were insufficient for computing higher order statistical moments directly and so were not used in the calculation of regional parameters. In this quarter, precipitation frequency values for SNOTEL stations were calculated using the regional growth factors (RGF's) of the regions in which they reside. The estimates will be used to anchor the spatial distribution of precipitation frequency residuals that will be the basis of the precipitation frequency maps (see Section 4.7).

4.4 Development of Software.

Internal consistency software was revised to adjust quantiles through the 48-hour duration for hourly-only stations. Cases where a shorter duration has an estimate that is higher than the next longer duration (e.g., 2-hr = 1.9 and 3-hr = 1.5) are mitigated with a practical adjustment using ratios based on the 1-hour duration.

Software was developed to adjust quantiles of co-located hourly and daily stations, particularly across the 12-hour to 24-hour durations where disparities occur due to gage differences. This adjustment assumes that the daily 24-hour quantiles are true because they are based on our most consistent values and generally have longer record lengths. The method preserves the hourly distribution for 60-minute through 12-hour quantiles at a given hourly station. It then adjusts the quantiles using ratios based on means and regional growth factors (RGFs) since these are the primary parameters in calculating quantile estimates and thus are the major contributors to any observed disconnect between the hourly 12-hour and 24-hour estimates. The software was modified to run on all co-located stations on a region-by-region basis.

Software has also been written to calculate conversion factors from annual maximum series to partial duration series. This software will be tested and run for all durations and return frequencies. The AMS to PDS ratios will be averaged for each region and reported in the final deliverable.

4.5 Trend and Shift Statistical Analysis.

It was found that the data are random and there are few stations (~15% of the tested stations) with significant linear trend or shift in mean in the data at the 90% confidence level. Stations that have a gap of 5 years or longer were not used. Stations with such gaps were identified and included if they could be truncated to have a continuous time series with 50 years or more. The 5-year gap criteria was chosen to maximize the use of limited data while still maintaining the integrity of the time series for the tests. Selected results of the statistical analyses are briefly given below.

4.5.1 Trend results.

The data were tested for a linear trend in annual maximum series using the linear regression model and t-test at the 90% confidence levels. Stations must have at least 50 years of data and be a continuous time series to be eligible for the linear trend test. 52 stations were not used because they were not continuous (i.e., they had a gap in record of 5 years or longer). Of 1449 stations, 735 (or 50.7%) were eligible for the test. Of those tested stations, 15.2% exhibited a linear trend in their annual maximum series (9.1% in a positive direction, 6.1% in a negative direction). Table 1 lists the linear trend results by state in the study area.

Table 1. Linear trend test results

State	passed	total trend	pos trend	neg trend	total tested	% stns with trend
Arizona	111	14	10	4	125	11.2
California	192	27	20	7	219	12.3
Colorado	34	6	2	4	40	15.0
Idaho	21	2	1	1	23	8.7
Nevada	34	6	2	4	40	15.0
New Mexico	115	21	13	8	136	15.4
Oklahoma	3	0	0	0	3	0.0
Oregon	5	2	2	0	7	28.6
Texas	24	4	3	1	28	14.3
Utah	79	28	12	16	107	26.2
Wyoming	5	2	2	0	7	28.6
Total	623	112	67	45	735	15.2

A test of the linear trend in variance was also conducted. Of the 735 stations tested, 12.7% exhibited a trend in the variance of annual maximums (3.3% in a positive direction, 9.4% in a negative direction). In other words, most stations that exhibited such a trend showed a decrease in variance. Table 2 lists the trend in variance results by state in the study area.

Table 2. Trend in variance results.

State	passed	total trend	pos trend	neg trend	total tested	% stns with trend
Arizona	116	9	5	4	125	7.2
California	198	21	9	12	219	9.6
Colorado	35	5	0	5	40	12.5
Idaho	22	1	0	1	23	4.3
Nevada	34	6	0	6	40	15.0
New Mexico	110	26	5	21	136	19.1
Oklahoma	3	0	0	0	3	0.0
Oregon	6	1	1	0	7	14.3
Texas	25	3	1	2	28	10.7
Utah	87	20	3	17	107	18.7
Wyoming	6	1	0	1	7	14.3
Total	642	93	24	69	735	12.7

4.5.2 Shift Results

The data were tested for shifts in mean between two time periods using the t-test and Mann Whitney non-parametric test at the 90% confidence levels. Both tests generally give the same results. The t-test provides a quantitative measurement of the percentage that the mean shifted from one time period to the next. The Mann Whitney is a qualitative test. Two dates for dividing the dataset into two time periods were tested (1958 and 1970). 1958 is the final year for which TP40 had data; 1970 is the final year for NOAA Atlas 2. Because the current dataset has more data in the more recent years, the 1970 division allowed more stations to be included. A minimum of 30 years in each data segment were required for a station to be eligible for the test for shifts in mean.

The results when using 1958 as the division are:

- t-test: 242 of 1449 (16.7%) were eligible. 14.1% of those tested had a shift in mean (8.7% increased in mean, 5.4% decreased in mean).
- Mann Whitney test: 243 of 1449 (16.8%) were eligible. 15.2% of those tested had a shift in mean. (This is a qualitative test and so a quantitative break-down is not possible.)

The results when using 1970 as the division are:

- t-test: 288 of 1449 (19.9%) were eligible. 13.2% of those tested had a shift in mean (7.0% increased in mean, 6.2% decreased in mean).
- Mann Whitney test: 193 of 1449 (13.3%) were eligible. 10.4% of those tested had a shift in mean. (This is a qualitative test and so a quantitative break-down is not possible.)

Table 3. Test for shift in mean results (1958 split).

State	passed	total trend	pos trend	neg trend	total tested	% change in mean
Arizona	38	4	3	1	42	6.6
California	50	9	7	2	59	9.3
Colorado	10	2	0	2	12	-15.0
Idaho	9	1	1	0	10	13.9
Nevada	15	4	1	3	19	-6.9
New Mexico	38	6	4	2	44	5.3
Oklahoma	1	0	0	0	1	0
Oregon	0	1	1	0	1	17.3
Texas	2	1	1	0	3	20.1
Utah	41	6	3	3	47	1.0
Wyoming	4	0	0	0	4	0
Total	208	34	21	13	242	4.2 (avg)

Table 4. Test for shift in mean results (1970 split).

State	passed	total trend	pos trend	neg trend	total tested	% change in mean
Arizona	44	5	2	3	49	-4.8
California	70	9	3	6	79	-4.2
Colorado	11	0	0	0	11	0
Idaho	11	1	1	0	12	27.9
Nevada	14	5	2	3	19	-8.3
New Mexico	45	8	6	2	53	9.7
Oklahoma	1	0	0	0	1	0
Oregon	3	0	0	0	3	0
Texas	11	1	1	0	12	25.0
Utah	40	9	5	4	49	1.3
Wyoming	0	0	0	0	0	0
Total	250	38	20	18	288	1.0 (avg)

4.6 Temporal Distributions.

To better correspond with precipitation frequency durations that have been computed for the study, 4-day temporal distributions of extreme rainfall will be presented instead of the previously decided 3-day duration. Temporal distributions for 12- and 24-hour durations have already been computed. Software has been written and the 4-day distribution data were extracted. These data will be used to complete the 4-day temporal distribution deliverable.

4.7 Spatial Interpolation.

On July 30, 2002 Geoff Bonnin and Tye Parzybok traveled to the Spatial Climate Analysis Service (SCAS) at Oregon State University, Corvallis, Oregon to discuss and obtain the first draft PRISM-interpolated Semiarid mean annual maxima (a.k.a. "index flood") grids for 1-hour and 24-hour. The successful all-day meeting covered the following items:

- To better understand how PRISM (Parameter-elevation Regressions on Independent Slopes Model) performs in spatially interpolating mean annual maxima values to grids
- Assessment of hard-copy maps (contoured) of the draft grids 1-hour and 24-hour "index flood"
- The evaluation of suspect data points and their influence on the grid results
- Inspection of model performance in difficult areas (e.g. transition between orographically-forced extreme regime in central New Mexico to a regime of more synoptically-forced events in eastern New Mexico)
- Differences between the NOAA Atlas 2 2-year 1-hour and 24-hour maps

It was concluded at the meeting that PRISM was doing an excellent job and was properly parameterized to spatially interpolate point index flood values.

Upon completion of the Semiarid observing-site peer review, there was justification provided by reviewer comments to make some adjustments to the precipitation frequency estimates, including the mean values. So 1-hour and 24-hour mean values were re-calculated and new draft "index flood" grids will be created using PRISM later this month.

The draft "index flood" grids allowed HDSC to fully test the precipitation frequency map derivation procedure, known as the cascade residual add-back (CRAB) procedure. The CRAB procedure provides a method to smooth discontinuities that may arise between regions as a result of the regionally estimated shape factors and in cases where stations did not conform to any region. A brief description of the process follows.

CRAB is a derivation process that utilizes the strong, linear relationship between a particular duration and frequency (e.g. 50-year 24-hour) and the next higher frequency (e.g. 100-year 24-hour). In fact, this relationship within a region is a constant obtainable from the regional growth factors. With the CRAB procedure however, a global (all-region) relationship is developed based on actual observing-site data, then the linear relationship is applied to the preceding grid (i.e. 50-year 24-hour) to establish a first guess 100-year 24-hour grid. Knowing regional differences occur, residuals (actual minus observed) are calculated for each observing-site and then normalized (divided by) by the preceding estimate (50-year 24-hour). These (point) normalized residuals are then spatially interpolated to a grid. The resultant grid is then de-normalized by multiplying it by the preceding grid to obtain a grid of actual residuals, in inches. The last step is to simply add the residual grid to the first guess grid to arrive at the final 100-year 24-hour grid. The process, as the term cascade implies, utilizes a previously derived grid to derive the next grid. So the same process is followed for deriving the 200-year 24-hour grid, but instead of the 50-year 24-hour grid being used as the predictor, the new 100-year 24-hour grid is used.

The updated draft "index flood" grids for the Semiarid Project, as well as a subset of actual precipitation frequency grids, will be subjected to review in the next month.

4.8 Precipitation Frequency Data Server.

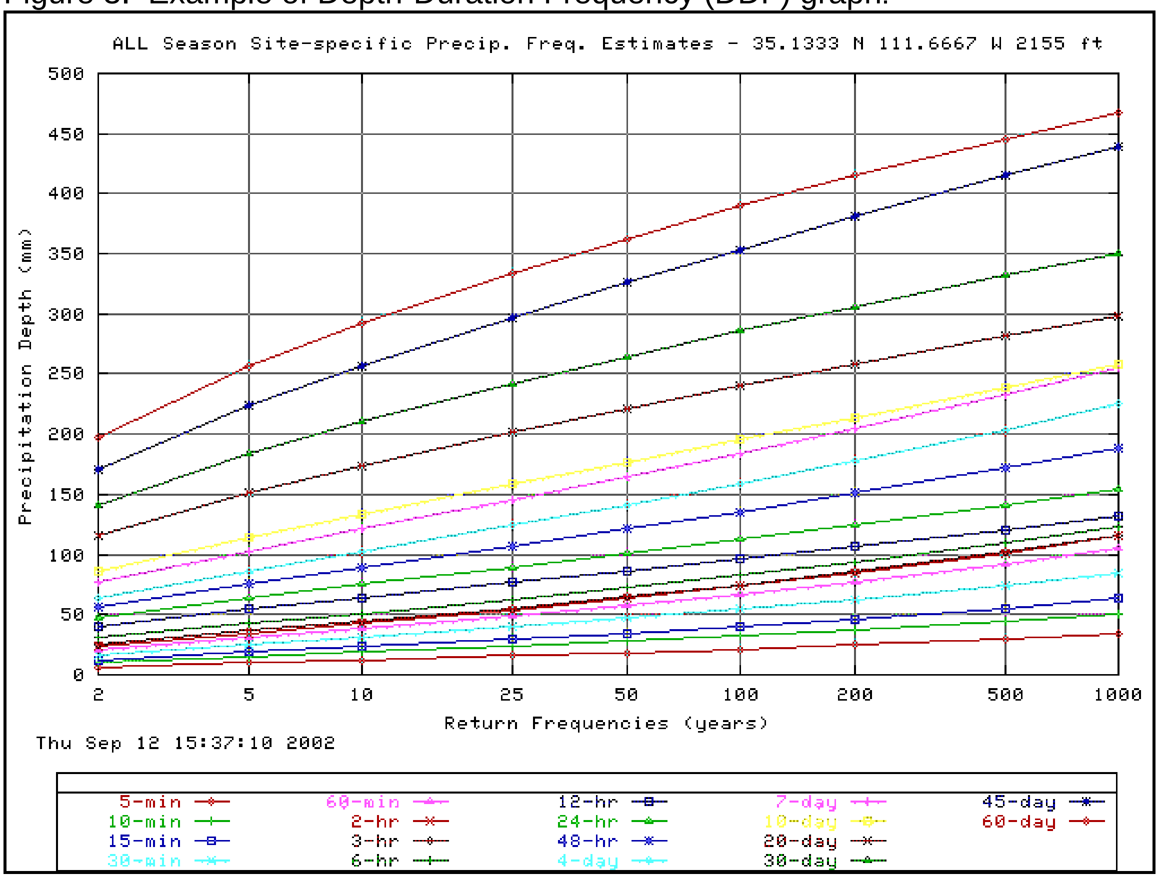
The Semiarid observing-site peer review allowed users to not only review the Semiarid precipitation frequency estimates, but the Precipitation Frequency Data Server (PFDS as well. The PFDS held up well during its first debut, and a tremendous amount of valuable input was received and quickly incorporated into the PFDS.

Such changes and bug fixes include, but are not limited to:

- Fixed data truncation at 100 inches problem
- Fixed the "Download table as text" function
- Added new Depth-Duration Frequency (DDF) graph (see below)
- Changed the titling of the x- and y-axis
- Added more "Submit" buttons to alleviate the confusion on how to get to the output page
- Modified the screen layout such that it fits comfortably on one screen (widthwise)
- Limited the list of stations in the pull-down menu to only those stations in the selected state

In order to provide users a complete perspective of precipitation frequency estimates, a new graph is now part of the precipitation frequency output page. An example of the popular new graph is shown in Figure 3.

Figure 3. Example of Depth-Duration Frequency (DDF) graph.



4.9 Documentation.

The outline for the final documentation of the Semiarid Project has been revised to reflect relatively recent changes in methodology. A detailed outline, which will include theme and length of each section, is being written. The documentation will include Introduction, Historical Review, Approach using L-moments, Methodology, a PFDS user's guide, Interpretation of Semiarid Results, Trend Analysis, Temporal distributions of heavy rainfall, Seasonality, and glossary. Many of the sections, Introduction through PFDS user's guide, will be applicable to all current HDSC projects.

4.10 Spatial Relations (Depth Area Duration Study).

Progress towards the development of depth-area-duration (D-A-D) reduction relationships for areas from 10 to 400 square miles continues. Four additional study areas (three in California and one in Arizona) have been identified and will likely be included in the D-A-D study. Quality control on the existing eight study areas has been completed. A new study area in the Middle Atlantic area may also be used. The initial computer programming has been written and successfully tested on two study areas. The secondary D-A-D programming continues and will be completed early in the next quarter. Upon completion, the final D-A-D reduction relationships will be available for use in basins throughout the United States.

Table 5. Dense Area Rain Gauge Networks in D.A.D. Study.

Depth Area Duration Study Areas	**Data Extraction & Re-Formatting**
Walnut Gulch, AZ	X
Reynolds Creek, ID	X
Tifton, GA	X
Hastings, NE	X
Alamogordo Creek, NM	X
Safford, AZ	X
Santa Rita, AZ	X
Cochocton, OH	X
Danville, VT	X
Chicago, IL (NCDC stations)	X
Riverside, CA	X
Maricopa County, AZ	X
Ventura County, CA	
Santa Clara County, CA	
Santa Barbara County, CA	

5. Issues.

5.1 AMS Conference

HDSC is presenting four papers/posters at the 83rd American Meteorological Society Annual Meeting in February of 2003. The papers include *Updating NOAA/NWS Rainfall Frequency Atlases*, which will give an overview of our approach, *Updated Precipitation Frequencies for the Semiarid Southwest United States*, which will present selected results from the Semiarid study, *Updated Precipitation Frequencies for the Ohio River Basin and Surrounding States*, which will present selected results from the Ohio study, and *NOAA/NWS Precipitation Frequency Data Server*, which will present the PFDS in detail.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Collection and Quality Control [complete]
L-Moment Analysis/Frequency Distribution [complete]
Temporal Distributions of Extreme Rainfall [complete]
Peer review of point estimates [complete]
Trend Analysis [October 2002]
Spatial Interpolation [November 2002]
Precipitation Frequency Maps [December 2002]
Final Report [December 2002]
Web Publication [December 2002]
Spatial Relations (Depth Area Duration Studies) [January 2003]

6.1 L-Moment Analysis/Frequency Distribution.

L-moment statistical analyses of annual maximum series are complete for all daily, hourly and n-minute data after adding several stations to the hourly dataset. Partial duration series have been generated and software has been written to compute the conversion factors from annual maximum series to partial duration series. The final partial duration results and conversion factors will be calculated in the next quarter.

6.2 Trend Analysis and Seasonal Analysis.

Statistical tests have been run on the completed 24-hour dataset to test for any trends or shifts in annual maximums through time. Documentation of the results is currently being written. The number of exceedences for given return frequencies and durations will be extracted and plotted for each month of the year. These will represent the seasonality of extreme rainfall. Both the trend and seasonal analyses will be completed in the next quarter.

6.3 Temporal Distributions of Extreme Rainfall.

Temporal distributions for extreme rainfall of 4-day duration will be completed during the next quarter.

6.4 Spatial Interpolation.

Revised data has been delivered to SCAS to produce revised spatial interpolation grids of the 1-hour and 24-hour mean values. These grids will be reviewed in the next quarter and revised based upon reviewer comments. Once we are satisfied with the results all “index flood” maps will be generated by SCAS and processed to produce precipitation frequency maps.

6.5 Peer Review.

A peer review of 1-hour and 24-hour “index flood” grids and 100-year return frequency maps will be conducted during the next quarter. Reviewer comments will be promptly addressed.

6.6 Documentation

Once the detailed outline of the final documentation is completed in the next few weeks, we will begin writing the final text for the Semiarid study. This will be completed during the next quarter.

6.7 Spatial Relations (Depth Area Duration Study).

The data for all study areas will be extracted and re-formatted during the next quarter. Software development for the DAD computations will be completed and the computations will be performed. If additional dense-area-networks are available, they will be added.

References

Frederick, R.H., V.A. Myers and E.P. Auciello, 1977: Five- to 60-minute precipitation frequency for the eastern and central United States, NOAA Technical Memo. NWS HYDRO-35, Silver Spring, MD, 36 pp.

Hershfield, D.M., 1961: Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years, *Weather Bureau Technical Paper No. 40*, U.S. Weather Bureau. Washington, D.C., 115 pp.

Hosking, J.R.M. and J.R. Wallis, 1997: *Regional frequency analysis, an approach based on L-moments*, Cambridge University Press, 224 pp.

Huff, F. A., 1990: Time Distributions of Heavy Rainstorms in Illinois, *Illinois State Water Survey*, Champaign, 173, 17pp.

Lin, B. and L.T. Julian, 2001: Trend and shift statistics on annual maximum precipitation in the Ohio River Basin over the last century. Symposium on Precipitation Extremes: Prediction, Impacts, and Responses, 81st AMS annual meeting. Albuquerque, New Mexico.

Miller, J.F., 1964: Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States, *Technical Paper No. 49*, U.S. Weather Bureau and U.S. Department of Agriculture, 29 pp.

Miller, J.F., R.H. Frederick and R.J. Tracy, 1973: Precipitation-frequency atlas of the western United States, *NOAA Atlas 2*, 11 vols., National Weather Service, Silver Spring, MD.